Supply chain dynamics of Indian agriculture: reference to information technology and knowledge management

Sazzad Parwez
Centre for Studies in Economics and Planning, School of Social Sciences, Central University of Gujarat, Gandhinagar, India

Purpose of review: This review explores the supply chain dynamics of agriculture in India; it highlights the current status of the infrastructure with respect to the use of information technology in agriculture and assesses the impact of an inadequate agricultural infrastructure on the supply chain and agriculture itself.

Findings: Most of the literature has indicated that the agricultural supply chain, starting from the input to the consumer, requires integration in order to achieve the objective of an efficient and effective supply chain mechanism. An efficient supply chain plays a very important role in the development of the agricultural sector. Therefore, the government and corporate sectors must address the issues of integration, infrastructure development, and information technology and management to achieve the objective of a feasible agricultural sector which will lead to food security for all. Innovations in postharvest technology and particularly in the development of infrastructure could help achieve this goal.

Directions for future research: Greater emphasis should be placed on problem oriented research, which employs integrated approaches to solve postharvest issues. Apart from the missing links in our understanding and implementation of agricultural food supply chains, proper linkages must be established in the agriculture and processing sectors.

Keywords: agriculture; information technology; infrastructure; food security; development; socio-economic; investment

Introduction

India has experienced remarkable growth in the production of various agricultural commodities over the last four decades. Technological intervention in mid-1960s contributed significantly towards bringing the country from a deficit to a surplus stage in food grain production. However, the recent trend of cropping pattern has created many problems related to sustainability and market imbalances, as it can be observed from instances of occasional poor monsoon and some demand-related problems that the long term trend of agricultural pattern and production in India can largely be attributed to a variety of factors such as declining public investment; failure to carry out essential reforms to conserve water and soil; unabated degradation of natural resources, and weakened support systems due to financial problems of state governments. While reversing the trend of declining investment in agriculture, which has often been cited as the most important factor for deceleration in growth, especially during the 1990s, could contribute significantly to reversing the observed deceleration in the growth of agriculture, it will not, however, be prudent to expect that investment alone will reverse this trend. Several studies suggest that the government’s reform policy only focused on price measures, ignoring infrastructure and institutional changes, which have caused an unfavourable effect on agricultural growth in recent decades. It has also been shown that there is a strong and positive impact of public investment on agricultural productivity and growth in India [1*, 2*], which has been declining over time. In contrast to this, in order to compete in the world market with the emergence of World Trade Organization (WTO), Indian agriculture needs more public investment and policy support in several areas to overcome prevailing structural weaknesses such as low scale of operation, high postharvest losses, poor rural infrastructure, a lack of product diversification, inadequate research and development (R&D) spending, low productivity, an absence of marketing infrastructure, and inadequate financial support.

Agricultural production is broadly categorized into these subsystems; input supply, production, processing, sales and distribution to consumer, and quality and food safety measures. Integration between these components is negligible throughout the agricultural sector in India. In practice, most of these components act independently and the flow of information between different components is either missing or very poor. Due to lack of coordination between various sub-systems, the agricultural system operates inefficiently at each stage of supply chain. A low level of adoption of high yielding seeds and other modern inputs shows that these inputs are not reaching the potential client effectively and completely. It is not only the purchasing power of farmers which hinders the adoption rate. Farmer insecurity about crop failure also prevents them from adopting changes. Likewise, at the production level, farmers usually do not make decisions based on market trends in a planned manner, nor do they plan the use of resources in an appropriate way.

The agricultural production system is still operating at a low scale with low productivity and high uncertainty in the country. There is little or no alignment between the growth of agricultural commodities in the market and the production and supply of these commodities. Despite faster growth and increased diversification in consumer food demand, there is still slow growth in the agricultural production sector in recent decades. The opportunity to strengthen growth in agriculture in India lies in value addition through agro processing, which is very low level at present. The agribusiness food processing industry is facing constraints and barriers such as: non-availability of adequate critical infrastructure facilities (cold chain, packing and grading centres); lack of adequate quality control and testing infrastructure; lack of suitable varieties of farm produce for processing; seasonality of raw materials; high inventory carrying cost; and high taxation and packaging costs [3*].

The consumption pattern in India is undergoing significant shifts towards high-value commodities like fruits, vegetables, milk, meat and eggs due to an increase in per capita income, urbanization, changes in lifestyle and preferences, relative prices and increased awareness among consumers about food nutrients [2*, 4*]. India’s consumer class is growing rapidly and becoming more and more attracted to the availability of fresh, convenient, palatable, nutritious and safe food. Besides, these consumers are able to make purchasing decisions based on criteria other than...
price constraints and, therefore, high-value processed food and beverages are gaining more space in shopping baskets. To meet these requirements the agricultural sector needs: intensive and new farming techniques to address new challenges for sustainable production and processing practices; it also needs to promote a balanced approach to the problems of food quality, safety, and good environmental management [5**].

Private sector organization investment in the agribusiness sector is low due to the high level of government regulations including procurement and movement, storage, warehousing and marketing of major commodities, plant- scale restriction in food processing, and restriction on contract farming and land leasing. However, the transformation in global food systems is leading to changes in food production and marketing in the form of emerging contractual and sharecropping relationships between private dealers and farmers, beyond direct government intervention [6**]. To promote private participation in the agribusiness and processing industry, most of the states in the country have already initiated amendments in the existing Agriculture Produce Marketing Committee (APMC) act to encourage direct marketing and contract farming programmes, in order to facilitate the process by which industries and large trading companies undertake procurement of agricultural commodities directly from farmers, and to establish effective linkage between farmers and the retail chain.

For strengthening agricultural production and productivity, the government had taken various initiatives, most of which were on the production side to ensure food security in the country. As a result, agricultural production in India experienced a remarkable growth after the mid-1960s with adoption of green revolution technologies. This growth led the country from being a food deficit country to a food surplus country, but at the cost of excessive utilization of natural resources; it also raised issues of sustainability in agriculture. The other crucial problem that constrains the growth of the agricultural sector is that public investment in agriculture as a percentage of Gross Domestic Product (GDP) has been declining gradually. A policy analysis of the agricultural system shows that there is multiplicity and duplicity of rules and regulations dealing with various components of the supply chain in agriculture. Lack of coordination among these, again, leads to the poor alliance and collaboration supply chain, which in turn leads to the inefficient product and information flow.

This review highlights the current status of the infrastructure in the context of information technology in Indian agriculture and assesses the impact of an inadequate agricultural infrastructure on supply chain and agriculture.

**Revolution in the agricultural supply chain**

Economic reforms and liberalization in the agricultural sector have emphasized the need for transforming Indian agriculture by designing a comprehensive supply chain model covering innovations at the farming level, which can help farmers regain profitability in a sustainable manner under changing conditions with proper assurance of market arrangement [8**]. In recent decades, the government has introduced a number of initiatives to strengthen market linkage and diversification in the agricultural production system [6**]. Some of the important areas of intervention are: reform in the agricultural marketing system to ensure private participation for establishing direct linkage with farmers; capacity building and infrastructure development in regulated markets; extension of road network and transportation, storage and warehousing; market intelligence system; and introduction of commodity trading by establishing commodity exchanges; However, changes are taking place at very slow pace. A close look at the flow of agricultural commodities in India suggests that there are multiple routes, most of which are not recorded. Organized procurement or flows of agricultural commodities are quite low and primarily takes place in the form of the government market intervention scheme, coupled with few special procurement licenses to private organizations and contract farming arrangements [9**].

Different models of supply chain management government, cooperatives, corporate houses and Multi National Companies (MNCs) have been initiated to improve production, strengthen linkages with farmers and market efficiency, particularly in high-value commodities [5**, 7**]. The inclination of leading corporate organizations in India towards investing in agribusiness chains is very vibrant, and a number of organisations, for example, Hindustan Unilever Limited (HUL) and ITC, have already entered or are planning to enter agribusiness activities. This trend is creating a new business environment for agribusiness operations. In the traditional business model, the flow of agricultural commodities is influenced by number of intermediaries who add costs but no value to the agricultural commodity chain. The new corporate entries are not just participating in chain to source their required raw material (mainly indirectly from the farming community), but are more focused on the primary source of agricultural produce. In this context, the development of direct linkages with farmers will attain greater importance. It has been very well realized by these corporate participants in the agribusiness chain that the leadership in the food business requires a keen understanding of supply chain dynamics for agricultural produce. The participants should have clear strategies for sourcing raw materials and distributing the final products to potential consumers efficiently and effectively.

Retailing in India is undergoing an unprecedented transformation with number of national and international organizations trying to capture the huge and exponentially growing consumer market. The Indian retail market is estimated to be worth around USD 350 billion [10**], and food retailing constitutes a major part of the overall retailing business. The list of business houses that entered retail business or are getting ready to do so includes Bharti (with Wal-Mart), Reliance industries Ltd., Mahindra Shubhlabh, the Birla’s, the Munjals, HUL, ITC, Adani Retail, RPG Retail and Godrej Agrovet. The liberalization of government policy towards FDI in retailing has enhanced the process of modern retailing in the country. At present FDI is not allowed in food and grocery retailing since it is only allowed in single brand retailing, where 51% FDI is allowed through the Foreign Investment Promotion Bureau (FIPB) route, where 100% foreign investment is allowed through an automatic route or they can enter in based on technical tie-ups [11**].

**ICT and agriculture**

There are various reasons for inefficiency in the agricultural production and supply system, but the factor that has attracted the most attention of policy makers in last decade has to do with lack of appropriate information and services related to agricultural practices [1**, 12**]. With the emergence of globalization, liberalization and privatization of agricultural economy, and an increasingly complex agribusiness environment, traditional models of information dissemination and service provision have failed to meet the growing information and service demand of the farming community [13**]. Modern agriculture is knowledge intensive and increasingly information driven; each participant in the supply chain thrives on timely and accurate information for various decisions. According to Adhiguru and Mruthyunjaya [12**], the implementation of ICTs proposes three unique strategies: (1) a close vertical supply chain network for agribusiness enterprises; (2) an open chain network with dynamically evolving partners and supply chain situations for public, non-governmental and multilateral organizations; and (3) a spatial data services network to address
natural resource management and its sustainability concerns. Therefore, knowledge and information are important factors for accelerating agricultural development by increasing agricultural production and improving marketing and distribution efficiencies \[5, 7, 14\]. In addition to connecting small farmers and artisans to markets, ICTs also facilitate most agricultural decisions; what to cultivate, how to cultivate and harvest, when and where to sell, and what price maximizes the returns. Effective decision making with respect to all these aspects ultimately determines efficiency in the supply chain.

Therefore, efficient and effective flow among various stakeholders of any business activity is key to strengthening supply chain efficiency. The major problem faced by the farming community and associated stakeholders is related to efficient and effective decision making at different stages of agribusiness activities, right from crop planning to the marketing of final produce. At each stage of farming a farmer requires data and information on a number of variables. In the absence of timely availability or non-accessibility of these data, farmers are not able to decide what, how, and how much to produce as per market needs. The fast and innovative development in ICTs can provide immense opportunities to public and private sector agencies to integrate these technologies in the supply chain systems. ICTs are extremely important for dissemination of information and provision of services, enabling various transaction and creating awareness among rural masses far removed from government. ICTs provide a modern, effective and speedy mode of interaction and communication that conveys new resources of knowledge and information to the society.

In order to disseminate information and provide different services in a cost-effective manner, numerous ICT initiatives are being made in many countries. The developing world is looking towards ICT systems for solving their numerous information-related problems. Literature argues that the use of ICT facilities free flow of information and makes available the services even to the most marginalised section of the society. Many public and private sector ICT-enabled initiatives have been undertaken in India in the last decade especially to cater to the needs of the agricultural or overall rural sector development. Some of these initiatives include e-Choupals by ITC, DCM Shriram Consolidated Limited (DSCL), Hariyali Kissan Bazar, Drishti, AgMarknet, Gyaandoot, iKisan, and Parry Kiosks by EID parry, etc.

All these ICT initiatives share the common objective of empowering rural communities to take the right decisions related to their day-to-day activities and thereby improve their performance. Since the rural economy in India or, for that matter, in any developing country, has a very strong linkage with agricultural economy, the major thrust of these initiatives has been the agriculture and allied sectors \[15\]. But integration between these models is poor due to the lack of proper coordination among various sub-systems in the supply chain. The Government of India (GOI) has formulated an ambitious National e-governance plan (NeGP), which identifies 25 mission mode projects, including agriculture, to be implemented through different ministries at the centre well state level.

**ICT initiative in Indian agriculture**

To promote ITC based e-governance in agriculture at the centre and provide support to states/UTs for the same, the National e-governance plan (NeGP) is also implementing a central sector scheme, ‘Strengthening/Promoting Agricultural Information Systems’ during the Tenth Plan with a budgetary provision of Rs 100.00 crore. The scheme has the following components: (i) development of agricultural informatics and communication; (ii) strengthening of IT apparatus in agriculture and cooperation in states and UTs (AGRISNET); (iii) IT apparatus at department headquarters and its field offices; (iv) Agricultural Resources Information Systems (AgRIS); and (v) Kisan Call Centres to accomplish the objective.

There have been some initiatives already taken in India, by using ICT in agriculture but in most of these projects impact on agriculture has been negligible so far mainly due to inefficient and ineffective implementation mechanisms. Indian experiences with IT projects are there with project such as: (i) the Gyandoot project in Madhya Pradesh; (ii) the Warana Wired Village project in Maharashtra; (iii) the Information Village project of the MS Swamina-
than Research Foundation (MSSRF) in Pondicherry; (iv) the i-Kisan project of the Nagariina group of companies in Andhra Pradesh; (v) Automated Milk Collection Centres of Amul dairy cooperatives in Gujarat; (vi) online marketing and CAD in Northern Karnataka; (vii) Knowledge Network for Grass Root Innovations—Society for Research and Initiatives (SRISTI) in Gujarat; (viii) Application of Satellite Communication for Training Field Extension Workers in Rural Areas by Indian Space Research Organisation; (ix) Tarahaat.com by Development Alternatives in Uttar Pradesh and Punjab, and many more are working toward utilization of IT and better knowledge management for development of effective supply chains and improvement of the socio-economic condition of rural people in India.

**Integrated knowledge model for agricultural supply chain in India**

Strengthening vertical relationships between various stages of production and processing in the agribusiness sector has always been an important area of empirical analysis by researchers and policy makers across the world. Vertical coordination in the Indian agriculture sector is limited to some selected high-value commodities such as poultry product, milk, fruits, and vegetables [16**]. Studies have suggested that vertically integrated agribusiness activities are reducing production costs among contract growers, as well as producer-consumer margins with a comparatively high involvement of smallholders [17**, 18**]. However the pace of change in supply chain integration and responsiveness of the production system towards a market-driven approach is slower in India compared with elsewhere in the world.

Farmers are still more comfortable growing the traditional crops, particularly rice and wheat, as they have already discovered the market for their marketable surplus, whether through the government procurement arrangement or private local traders. But the shift in market demand needs a balancing approach to meet the supply of deficit commodities such as pulses, oil seeds and high-value food items.

This balancing of demand and supply can be ensured by strengthening buyer-supply relationships in an efficient way, and disseminating accurate and timely information to all the participants of the business chain. The major issues in the Indian agribusiness supply chain is lack of integration between different sub-systems of the chain (Figure 1). Each participant in the chain acts as an independent agent with a very low level of business relationship. Based on practical experiences, Grimsdell [19] proposed six fundamental requirements for an efficient supply chain between vegetable growers and major retail customers: scale of operation, strategic alliances, production flexibility, continuity of supply, quality control, and communication. These parameters are very relevant while establishing a supply chain community between farming community, processors, handlers, government and consumers in the country to ensure a cost effective and safe flow of agricultural commodities through the chain, which requires extended relationship between the supply chain stakeholders. Collaboration and relationship management along the chain is a key instrument for integrating the supply chain system and the ability to establish effective relationship is necessary to reach supply chain success.

Several studies have suggested that the increased need for collaboration is a way to construct even more efficient and responsive supply chains, in order to deliver exceptional value to customers. According to Matopolous et al. [18**], there are two major pillars of supply chain collaboration – the design and governance of supply chain activities, and the establishment and maintenance of supply chain relationship (Figure 2).

The success of collaboration depends largely on the physical structure of the chain flow and the way relationships among various channel members are maintained in the system. An efficient physical flow system needs a governance mechanism for organizing and controlling the activities as per design. The physical structure and governance of conventional supply chains in India shows that these chains generally exclude the primary stakeholders of agricul-

Figure 2: Framework of supply chain collaboration (adapted from [18**]).
tured, i.e., the farmers, from the system [20, 21], and the supply chain of agribusiness firms start from the raw material sourcing from the traders and wholesalers of agriculture commodities. One of the major reasons for this kind of arrangement may be government regulation or direct procurement from the farming community.

The recent policy changes and amendments in the existing Agriculture Produce Marketing Committee (APMC) Act by state government provide an opportunity for private firms to extend their supply chain to the farm level. The design of a supply chain governance system depends on an efficient flow of information on various aspect of the chain, such as numbers of participants required at each stage, i.e., selection of partners; types of goods and services required to strengthen the relationship, i.e., with supply chain activity; and level of decision making required [22, 23].

The sustainability of supply chain collaboration largely depends on how relationships are established and maintained among chain partners. Generally, business relationships are maintained by adopting two basic approaches; behavioural and economic. A balance between risk and reward is considered to be an important economic factor for enhancing relationships. Similarly, trust among channel partners, power share and interdependence are other important factors for enhancing relationships in the supply chain system [3, 24, 25]. Institutions play important roles in strengthening the markets for commodities produced, bought and sold by smallholders, enabling collective action and redressing missing markets.

**Conclusion**

Based on the above assessment, this paper examines the critical issues at each sub-system of agriculture supply chain, starting from the input to the consumer, with a view to integrating them in efficient and effective manner. Thus, this paper broadly covers important aspects of agriculture supply chain in India- identification of issues at different levels in the supply chain; transformation in the agriculture due to various supply chain interventions; the role of ICTs in supply chain management: and this paper also covers the suggestion to improve efficiency at different levels in supply chain. As proper flow of information across the chain constitutes an integral part, the role of information and communication technologies (ICTs) in improving supply chain efficiency in agriculture discussed in detail. Technical intervention and policy issues have also been discussed for suggesting appropriate ways for the integration of each sub-system of the agricultural supply chain.

As pointed out before greater emphasis should be placed on problem-oriented research, which employs integrated approaches to solve postharvest issues. Apart from the missing links in our understanding and implementation of agricultural food supply chains, proper linkages must be established in the agriculture and processing sectors. Innovations in postharvest technology and particularly in the development of infrastructure could help to achieve this goal. The processing of fruits and vegetables for export, particularly in the development of infrastructure could help to achieve this goal. The processing of fruits and vegetables for export, particularly in the development of infrastructure could help to achieve this goal. The processing of fruits and vegetables for export, particularly in the development of infrastructure could help to achieve this goal. The processing of fruits and vegetables for export, particularly in the development of infrastructure could help to achieve this goal. The processing of fruits and vegetables for export, particularly in the development of infrastructure could help to achieve this goal.